ACID-BASE

1. Hypochlorous acid, HOCl, is a weak acid commonly used as a bleaching agent. The acid-dissociation constant, K_a is 3.2×10^{-6}.

(a) What volume of 0.56-molar NaOH is required to completely neutralize 40.0 milliliters of 0.14-molar HOCl?

(b) Write the ionization reaction for HOCl in water.

(c) Calculate the pH of a 0.14-molar solution of HOCl.

(d) Calculate the percent ionization for part (c).

(e) Calculate the percent ionization for a solution that contains 3.8 grams of sodium hypochlorite, NaOCl and 100. mL of 0.14-molar HOCl.

(f) Write the net ionic equation for the reaction that occurs at the equivalence point and calculate the numerical value of the equilibrium constant for the reaction.

(g) Calculate the concentration of the hypochlorite ion (ClO^-) ion at the equivalence point.

(h) Calculate the pH at the equivalence point.

(i) Calculate the pH after 5.0 milliliters of 0.56-molar NaOH is added to 40.0 milliliters of 0.14-molar HOCl.

(j) Calculate the pH of a solution made by combining 40.0 milliliters of 0.14-molar HOCl and 7.0 milliliters of 0.56-molar NaOH.

(k) Calculate the pH after 15.0 milliliters of 0.56-molar NaOH is added to the 40.0 milliliters of 0.14-molar HOCl.

(l) Household bleach is made by dissolving chlorine gas in water, as represented below.

$$Cl_{2(g)} + H_2O \text{ --> } H^+ + Cl^- + HOCl_{(aq)}$$

Calculate the pH of such a solution if the concentration of HOCl in the solution is 0.065 molar.

(m) In part (j), calculate the concentration of the hypochlorite ion (ClO^-).

2. Methylamine CH_3NH_2, is a weak base that ionizes in water.

(a) Write a balanced chemical equation for the ionization of methylamine, CH_3NH_2, in water.

(b) At 25°C the percentage ionization in a 0.160 molar solution of CH_3NH_2 is 4.7%. Calculate $[OH^-]$, $[CH_3NH_3^+]$, $[CH_3NH_2]$, $[H_3O^+]$, and the pH of a 0.160 molar solution of CH_3NH_2 at 25°C.

(c) Calculate the value for K_b, the ionization constant for CH_3NH_2, at 25°C.

(d) If 0.050 mole of crystalline lanthanum nitrate is added to 1.00 liter of a solution containing 0.20 mole of CH_3NH_2 and 0.20 mole of its salt CH_3NH_3Cl at 25°C, and the solution is stirred until equilibrium is attained, will any $La(OH)_3$ precipitate? Show the calculations that prove your answer. (The solubility constant for $La(OH)_3$, $K_{sp} = 1 \times 10^{-19}$ at 25°C)

3. The molecular weight of a monoprotic acid HX was to be determined. A sample of 15.126 grams of HX was dissolved in distilled water and the volume brought to exactly 250.00 milliliters in a volumetric flask. Several 50.00 milliliter portions of this solution were titrated against NaOH solution, requiring an average of 38.21 milliliters of NaOH. The NaOH solution was standardized against oxalic acid dihydrate, $H_2C_2O_4 \cdot 2H_2O$ (molecular weight: 126.066 gram mol^{-1}). The volume of NaOH solution required to neutralize 1.2596 grams of oxalic acid dihydrate was 41.24 milliliters.

(a) Calculate the molarity of the NaOH solution.

(b) Calculate the number of moles of HX in a 50.00 milliliter portion used for titration.

(c) Calculate the molecular weight of HX.

(d) Discuss the effect of the calculated molecular weight of HX if the sample of oxalic acid dihydrate contained a nonacidic impurity.

4. (a) Specify the properties of a buffer solution. Describe the components and the composition of effective buffer solutions.

(b) An employer is interviewing four applicants for a job as a laboratory technician and asks each how to prepare a buffer solution with a pH close to 9.

Archie A. says he would mix acetic acid and sodium acetate solutions.

Beula B. says she would mix NH_4Cl and HCl solutions.

Carla C. says she would mix NH_4Cl and NH_3 solutions.

Dexter D. says he would mix NH_3 and NaOH solutions.

Which of these applicants has given an appropriate procedure? Explain your answer, referring to your discussion in part (a). Explain what is wrong with the erroneous procedures.

(No calculations are necessary, but the following acidity constants may be helpful: acetic acid, $K_a = 1.8 \times 10^{-5}$; NH_4^+, $K_a = 5.6 \times 10^{-10}$)

5. The overall dissociation of oxalic acid, $H_2C_2O_4$, is represented below. The overall dissociation constant is also indicated.

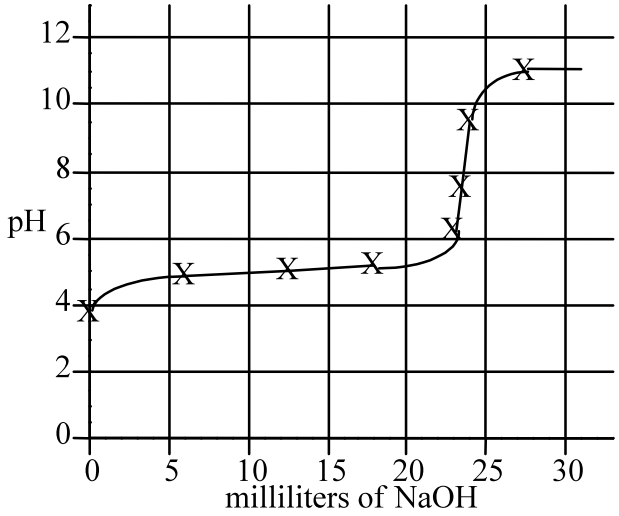
$$H_2C_2O_4 \text{ <=> } 2\ H^+ + C_2O_4^{2-} \qquad K = 3.78 \times 10^{-6}$$

(a) What volume of 0.400-molar NaOH is required to neutralize completely a 5.00×10^{-3}-mole sample of pure oxalic acid?

(b) Give the equations representing the first and second dissociations of oxalic acid. Calculate the value of the first dissociation constant, K_1, for oxalic acid if the value of the second dissociation constant, K_2, is 6.40×10^{-5}.

(c) To a 0.015-molar solution of oxalic acid, a strong acid is added until the pH is 0.5. Calculate the $[C_2O_4^{2-}]$ in the resulting solution. (Assume the change in volume is negligible.)

(d) Calculate the value of the equilibrium constant, K_b, for the reaction that occurs when solid $Na_2C_2O_4$ is dissolved in water.



6. A 30.00 milliliter sample of a weak monoprotic acid (HA) was titrated with a standardized solution of NaOH. A pH meter was used to measure the pH after each increment of NaOH was added, and the curve above was constructed.

(a) Explain how this curve could be used to determine the molarity of the acid.

(b) Explain how this curve could be used to determine the dissociation constant K_a of the weak monoprotic acid.

(c) Write a balanced chemical equation for the reaction at the equivalence point. What information is needed to find the equilibrium constant for this reaction?

(d) If you were to repeat the titration using a indicator in the acid to signal the endpoint, which of the following indicators should you select? Give the reason for your choice.

Methyl red	$K_a = 1 \times 10^{-5}$
Cresol red	$K_a = 1 \times 10^{-8}$
Alizarin yellow	$K_a = 1 \times 10^{-11}$

(e) Sketch the titration curve that would result if the weak monoprotic acid were replaced by a strong monoprotic acid, such as HCl of the same molarity. Identify differences between this titration curve and the curve shown above.

(f) If a solution of acetic acid, CH_3COOH, ($K_a = 1.8 \times 10^{-5}$) is titrated with hydroxylamine, $HONH_2$, ($K_b = 9.1 \times 10^{-9}$) to the equivalence point, will the resulting solution be acidic, basic or neutral. Explain your prediction.

7. In water, hydrazoic acid, HN_3, is a weak acid that has an equilibrium constant, K_a, equal to 2.8×10^{-5} at 25°C. To a 150. mL sample of a 0.050 molar solution of the acid is added 0.80 gram of sodium azide, NaN_3.

(a) Calculate the pH of the resulting solution at 25°C if the volume of the solution remains unchanged.

(b) To the above solution, 24.0 mL of 0.100 M HCl is added. Calculate the pH of the resulting solution.

(c) What is the pH when 10.0 mL of 0.100 M NaOH is added to the solution in part (b)?